Fuel Awareness

Fuel-related accidents occur at the rate of more than one per week.

Almost Home

You're almost home. Through your headphones the engine beats louder as you wait for the sound of silence, and the knot in your stomach grows larger as time and the airplane seem to slow down. Your last refueling opportunity is well behind now. It will surely take longer to turn around than to press on and you wonder if backing off on the power will make a difference. But the airplane's going so slowly now you decide to leave things as they are. One good thing about this ground speed – it gives you plenty of time to pick out suitable landing sites – at least in daylight. But night fell an hour ago and your pilot's sense – what little you possess at the moment – tells you that surviving a forced landing now will be more a matter of luck than skill. It's cool in the airplane but sweat stings your eyes as you search for the familiar airport lights over your nose.

Fifteen minutes later you shut down in front of your hangar. For once the fuel truck is waiting for you and you wish the lineman had tarried long enough for you to get some strength in your legs, but he's probably as anxious to get home as you were an hour ago. The lineman shakes his head and you shudder when you see how much fuel went into your airplane. As you lock the hangar you mumble thanks for the preservation of fools along with a promise to never do this again. It's early but the last hour has left you unbelievably tired, and it's an effort to stay awake and focused for the short drive home.

This is how many fuel exhaustion accidents develop. Through a combination of circumstances and a few, as NASA might put it, "non-optimal" decisions, otherwise prudent pilots crash short; often in sight of their destination. Most pilots can recall a time or two when they dipped into the reserves and most vow never to do it again. But somebody does it.

Fuel-related accidents occur at the rate of more than one per week. In one year 51 fuel exhaustion accidents occurred and, although there was nothing to fuel a post-crash fire, four were fatal. In that same year another 13 accidents were attributed to fuel starvation and two, one of which was fatal, were caused by fuel contamination.[1]

[1] Air Safety Foundation Nall Report - 2000

There is much that pilots should know about fuel and fuel management. In the following pages we'll discuss these subjects in detail but first let's look at the five things you can do to reduce your chances of having a fuel-related accident:

1. **Know How Much Fuel You Have -** You can't know how far you can go unless you know how much fuel you have, but knowing that isn't always easy.

   - The first step in knowing how much fuel you have is to ***think of fuel not in gallons or pounds but hours and minutes.*** Why think in time rather than distance? Because fuel burn is a constant – the engine, barring a malfunction, will always burn the same amount at any given combination of altitude, power setting, and mixture setting, but range will vary constantly due to changing winds and ground speeds. In order to know how much time you have, you must also know the rate at which your fuel is being consumed. That means an intimate knowledge of your engine's fuel consumption. The POH figures will get you close to the answer but only experience will tell you for sure. **Note: The Air Safety Foundation recommends that pilots of unfamiliar airplanes add one or two gallons per hour to their computed fuel consumption until they see how much that airplane actually burns.**

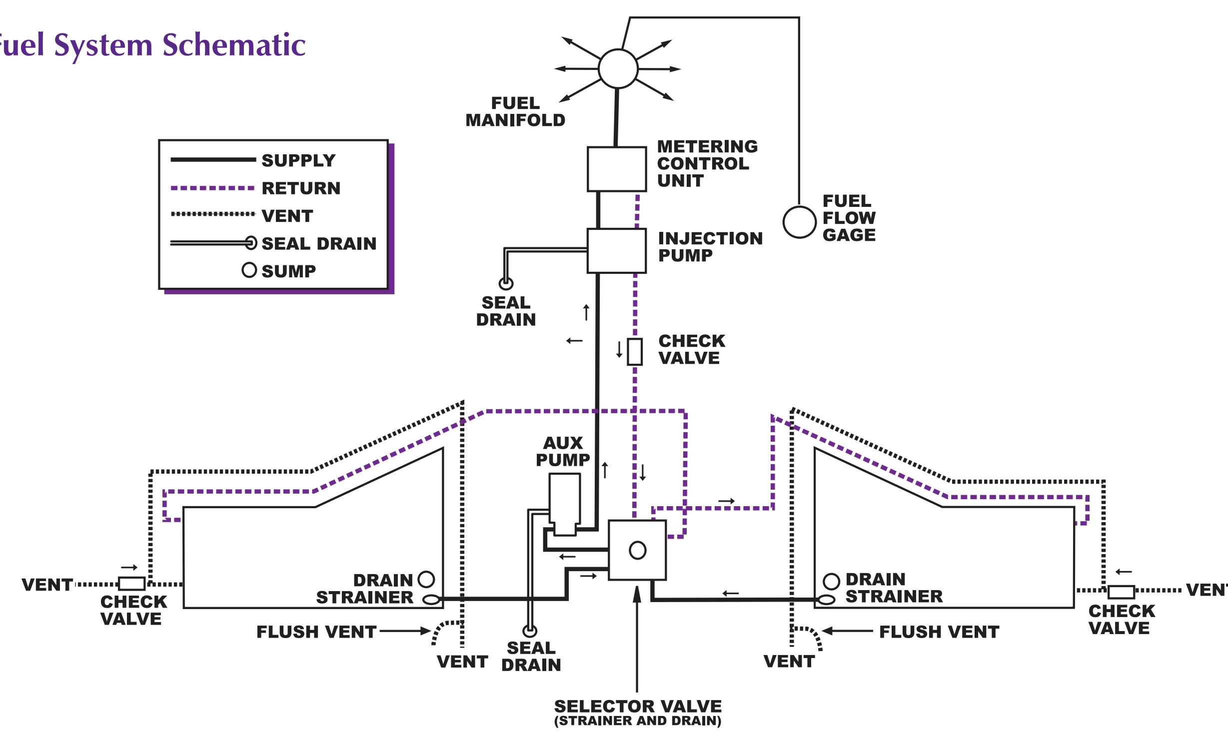
     Some airplanes are equipped with fuel flow computing devices that actually measure the fuel that is drawn from the tanks. These devices will indicate your consumption rate, but there's another part of the problem.

   - Next you'll have to know for certain how much usable fuel is actually on board. Fuel computers will tell you how much you're burning and how much you have left but pilots must input the fuel quantity, so the old computer adage applies – garbage in equals garbage out. A calibrated dipstick is a good way to measure fuel but be sure it's calibrated for your airplane. Some airplane models have several options for fuel tank capacity, i.e. a dipstick calibrated for a Cessna 182 with bladder tanks will indicate more fuel than is actually present in a 182 with metal tanks.

     Departing with full tanks is a good tactic but that isn't always possible. Most airplanes exceed weight and balance limitations with full fuel, all seats occupied, and maximum baggage. Some airplanes can be difficult to fuel completely. And what about the pilot before you who says, "I only flew an hour off of full tanks"? Were they really full? Did the pilot lean or was he operating full rich? What was the fuel consumption rate for the previous flight? Trust but verify. It's your safety and certificate on the line, not his.

2. **Know Your Airplane's Fuel System -** Pilots must also be familiar with and proficient in operating

Fuel System Schematic



the fuel system on their airplanes. Fuel management on a Cessna 150 training airplane is easy. Two wing-mounted tanks simultaneously gravity feed fuel to the engine. The fuel selector is either on or off. Compare this with a low-wing single boasting two main, two wing auxiliary, and two after-market tip tanks with an engine-driven primary fuel pump, electric boost pump, and electric fuel transfer pumps. It's not surprising that some pilots have made forced landings with fuel still available.

A student pilot was flying a Piper Arrow on a solo cross-country flight. While flying over a large metropolitan area the engine stopped due to fuel starvation. The student successfully navigated to a small airport and made a forced landing. The airplane was substantially damaged during the landing but the student was uninjured. A post-landing examination discovered one fuel tank empty and the other about half full – enough fuel to fly for at least 90 minutes. The student recalled completing the engine failure checklist as taught by her instructor. The list, including switching fuel tanks, was spoken as each item was touched but nothing was moved. In the heat of the moment the student reverted to early learning and performed the checklist twice exactly as she'd been taught. As she recited the list she touched each control but ***didn't move them.***

3. **Know What's in Your Fuel Tanks -** Pilots must ensure their airplane contains the proper grade of uncontaminated fuel. We've all been trained to drain the fuel tank sumps during preflight to make sure the airplane's been serviced with the proper grade of fuel and there are no contaminants. Fuel drains are, however, the second line of defense. Pilots and aircraft operators should take steps to prevent contaminants from entering the fuel supply in the first place. For example, most water contamination enters airplane fuel tanks through worn or defective fuel cap seals.

   Most aircraft fuel suppliers take great care to ensure an uncontaminated product is delivered to their customers but occasionally contaminated fuel is pumped into an airplane. There are also cases where line personnel have serviced airplanes with the wrong fuel. That's why it's important to supervise the fueling and sample the fuel after each delivery.

In the 1970s, airplane manufacturers started to identify turbocharged models with racing stripes and text. A large ***Turbo*** on the engine cowl triggered a rash of misfuelings with turbine fuel. Overt turbo marketing ended as quickly as it began, but there are still some airplanes out there with the original markings. Pilots of these craft should supervise every fueling.

Today there is a movement to install turbine engines on airplanes originally designed for reciprocating engines. Misfueling one of these aircraft with avgas would not be fatal to the engine, but if the mistake were made the other way around and a recip. engine airplane got a load of jet fuel the result could be disastrous. ***Pilots of Piper Malibus and Mirages should be especially careful that their airplanes aren't mistaken for the turbine-engine Meridian.***

4. **Update Your Fuel Status Regularly During Flight -** It's good to do thorough preflight planning but, once in the air, things can change. Winds are rarely exactly as forecast and weather deviations add miles and minutes to your trip. The Air Safety

Foundation recommends that pilots evaluate their fuel status each hour. If you know how many minutes of fuel you have and how long it will take to reach your destination or fuel stop, it's easy to know if you'll be needing your reserve. And speaking of reserves:

5. **Always Land with Adequate Reserve Fuel -** Aviation regulations require different fuel reserves for different operations. For instance: The regulations require flights conducted under IFR to have enough fuel to go from A to B, shoot the approach, execute a missed approach, fly to the alternate, and then be able to fly for another 45 minutes at normal cruise speed, not throttle back to milk the maximum endurance from the machine. ***The Air Safety Foundation recommends that pilots never land with less than one hour of fuel in the tanks. That way all the regulatory reserve requirements are met and exceeded by at least 15 minutes.***

Now that we've introduced the big five let's add some detail.

A Little History

The earliest airplanes used automobile, motorcycle, or tractor engines, and low octane automotive gasoline was sufficient to power them. But with the introduction of high compression engines and the special requirements of flying machines, aviation gasoline – avgas – was developed. Volatile, low octane fuel burned too easily in high compression engines. This resulted in combustion before the spark plug fired while the piston was still compressing the air/fuel mixture. To prevent this damaging preignition or detonation, lead was added to avgas to slow down the combustion process. The combustion quality of fuel is expressed as an octane number. Paradoxically the higher the octane, the more resistant to burning will be the fuel.

Early engines were notoriously unreliable, so pilots who survived their profession were quite proficient at forced landings. When the engine quit and the propeller (stick) stopped turning, the result was usually a ***dead stick landing.*** Knowing that each minute could be their engine's last, the pioneers endeavored to always have a suitable landing field within gliding range – a tactic that today's pilots would do well to emulate.

Compression and octane continued to rise through World War II when high compression military engines required an octane rating of 140. Under certain circumstances even 140 octane avgas would preignite, so at very high power settings some military engines injected water into the cylinders to slow down combustion. The 1950s saw the introduction of turbine engines, and although the early turbines ran on avgas, jet fuels were developed to optimize their performance. **[Note: Jet fuel burns hotter and more easily than any avgas and although turbines can run on avgas, reciprocating engines will be damaged or destroyed if operated on jet fuel.]** Military and commercial aviation quickly adopted the higher performance and more reliable turbines, and by the mid-1960s reciprocating engines were used almost exclusively in general aviation applications. During the 1960s, 140 octane gasoline gradually disappeared but avgas development continued. Today 100 low lead, color dyed blue, is the most common avgas; but 80, red, and 100 octane, green, avgas can still be found.

Avgas Composition

Avgas is required to be an all hydrocarbon product. This means that the components must be chemicals that contain only carbon and hydrogen atoms. The use of chemicals that contain oxygen atoms, alcohol compounds, and ether compounds is not permitted. Approved additives are alkyl-lead anti-knock additives, color dyes for identification, and other additives that improve storage stability and stop gum formation.

Lead is a pollutant and Environmental Protection Agency requirements resulted in low lead gasoline for cars and airplanes. As the EPA continues to reduce the amount of lead in all types of gasoline, the formulation of avgas will probably move away from lead as an additive.

Avgas: Riding a Fine Line

Avgas must easily vaporize and mix with air prior to combustion. If avgas remains in the (original) liquid state, it will wash lubricant from the cylinder walls, causing engine wear and diluting crankcase oil. In carbureted engines, fuel that does not vaporize quickly is not distributed evenly in the cylinders. On the other hand, if the fuel vaporizes too easily, it can cause vapor lock, carburetor icing, and excessive fuel loss through fuel tank vents. Avgas manufacturing and control specifications ensure that the gas you put in your tank will not be too liquid nor vaporize too easily.

Jet Fuel Is Different

Jet fuel is very different from avgas. Similar to kerosene, jet fuel burns at much higher temperatures than avgas engines can withstand. Most jet fuel dispensing nozzles are wide and flat while avgas nozzles are thinner and round. New airplane fuel tank openings are too narrow to accept jet fuel nozzles and many older airplanes have retrofitted restricting rings in their fuel tanks to prevent misfueling. But don't count on technology to ensure proper fueling. **The Air Safety Foundation strongly recommends supervising every fueling,** making sure that the type of fuel and amounts are correct. If that's not possible, be sure to cross-check the fuel ticket for type and amount in addition to sampling the fuel in your airplane.

Can I Use Automobile Gas in My Airplane?

Although automobile gasoline can be used in some airplanes, remember that airplane engines are designed to run on avgas. For a number of reasons, your airplane might not be able to use automobile gas:

- Automobile gas has much looser manufacturing specifications and quality control is less stringent, so quality and performance vary widely.
- Because of less careful handling, the risk of contamination is greater for automobile gas.
- Physical and chemical property differences can lead to poor fuel distribution, poor anti-knock properties, and excessive motor oil dilution. Additionally, automobile gasoline is less stable and is more likely to gum up.
- Because automobile gasoline is more volatile than avgas, it is more prone to loss through excess vaporization, vapor lock, and carburetor icing.

However, many pilots use automobile gasoline in their planes successfully. This is possible by having an Inspection Authorized (IA) mechanic complete modifications to the plane mandated by a Supplemental Type Certificate (STC). After the STC has been completed for your airplane, you will be allowed to use 80- or 100-grade automobile gasoline, depending upon the type of certification. For more information on the Automobile Fuel Program, see ***Auto Fuel in General Aviation Aircraft*** – a publication of the AOPA Aviation Services Department. **Note: Although plastic gas containers are increasingly common, it is impossible to properly ground them. Always use a metal gas can and ground it to the airframe. This will prevent the possibility of fuel ignition due to static electricity.**

Aircraft Fuel Systems

General aviation airplanes carry fuel in one or more main fuel tanks and some have auxiliary tanks as well. Fuel tanks are predominately metal but some airplanes have synthetic rubber bladders to contain the fuel. In rare cases a number of tanks may be interconnected and filled through one opening, but usually each tank has a capped opening to fill the tank, a fuel line to the engine, and, in fuel-injected designs, a return line to convey excess fuel from the engine back to the tank. Each tank also has one or more vents to admit air to the tank and one or more drains to sample fuel for correct type and grade, water, and other contaminants. If the tanks were not vented they would collapse as fuel is consumed. Some tanks have external indicators or internal tabs to help pilots gauge how much fuel is contained within them. Each airplane will also have a means of selecting which tank or combination of tanks is in use and of shutting off all fuel to the engine. Some airplanes such as the Cessna 150/152 feed from two

tanks at the same time. The fuel selector valve has an on and an off position. Other airplanes such as the C172 have off, left, both, and right positions for the fuel selector valve. Most low-wing singles are not able to feed from both wing tanks at the same time.

Caution: The location of the fuel selector valve varies and in some designs the valve is hard to see. To avoid the sudden silence of a fuel-starved engine and the subsequent expressions of concern from their passengers, pilots must be sure they are moving the fuel selector correctly. This may mean moving the pilot's seat and using a flashlight – especially at night. Obviously switching tanks should not be done at low altitudes. Perform pre-landing fuel tank selection before reaching pattern altitude.

Most GA airplane fuel tanks are located in the wings but some models have fuselage tanks. Some designs incorporate wingtip fuel tanks as the main fuel supply. Other tip tank designs carry auxiliary fuel. Auxiliary fuel may flow directly to the engine or to a main tank to replace fuel already consumed. Because fuel is a consumable resource that has weight, airplane designers try to locate tanks on or near the center of gravity. That way lateral balance is maintained within an acceptable range as fuel is burned.

Fuel often flows by gravity if the fuel supply is higher than the engine. Most carbureted high-wing designs incorporate gravity feed. Most higher power and high-altitude, high-wing designs also have an auxiliary fuel pump. If the fuel supply is lower than the engine, fuel must be pumped. Most low-wing designs have at least two fuel pumps. The main pump is usually mounted on the engine and driven mechanically. An auxiliary electric fuel pump may be used for priming, high-altitude flight, or as an emergency pump should the mechanical pump fail.

Some planes have an altitude compensating engine-driven fuel pump. This type of pump will compensate automatically for altitude changes. You don't have to reset the mixture unless you're going to increase power beyond 75 percent. An example of this would be to prepare for a go-around before landing.

Caution: Fuel pump configuration and use varies from one model to another and sometimes within a model. Some designs require the boost pump to be on for landing and takeoff; in other designs the boost pump is used only for high-altitude operation or when the mechanical pump fails. Pilots must be familiar with fuel pump operation for each airplane they fly.

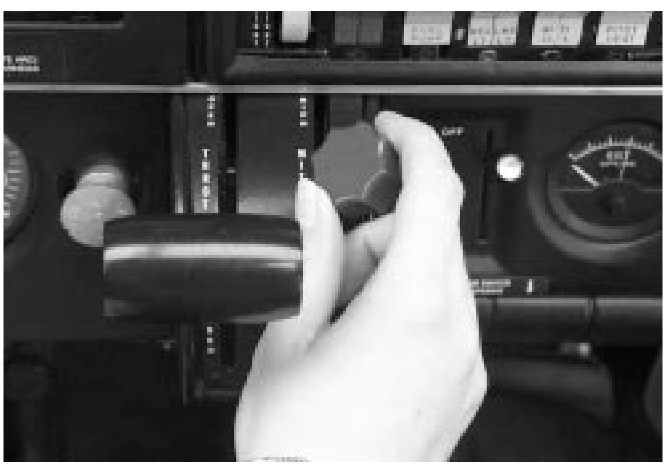
Finally, some sort of fuel quantity indication is provided for the pilot. It may be as complex as a fuel computer that measures fuel withdrawn from the tanks or as simple as a float connected to a wire that passes through the fuel filler cap. Most airplanes have a fuel gauge for each main tank but some share gauges among tanks. Pilots of these airplanes select which tank to gauge with an electric switch. Some gauges have a yellow arc on their faces. Because maneuvering on the ground or in the air could move fuel in the tank away from the outflow ports, fuel represented by the yellow arc should only be used in cruise. Even if there is no yellow arc on the fuel gauge, pilots should avoid sharp turns when entering the runway before takeoff if fuel tanks are not full.

How Fuel Works

Fuel is pumped or gravity fed from the fuel tanks to the engine. At the engine, it is mixed with air in a carburetor or injected directly into the cylinders where it is ignited by spark plugs. The resulting explosion drives the piston down and turns the crankshaft which, either directly or in some cases through a gearbox, turns the propeller. Fuel cannot burn without oxygen and, in order to achieve optimum efficiency, fuel and air must be mixed in the right proportion. The volume of oxygen available for combustion is determined by air density, which is a function of altitude, temperature, and humidity. Therefore, for any throttle setting/altitude/temperature combination there will be a given amount of oxygen. Using the mixture control, pilots adjust the amount of fuel to achieve the proper air-to-fuel ratio. Reducing the fuel flow is called ***leaning the mixture.*** Increasing the fuel flow is called ***enriching the mixture.*** Even in a properly leaned engine, not all the fuel that reaches the cylinders is burned. Some of the unburned fuel contributes to engine cooling before it leaves the airplane through the exhaust system.

Why We Have to Lean

The performance, range, and endurance figures for your airplane, listed in the *Pilot's Operating Handbook* (POH), are based on a ***properly leaned*** engine flying in optimum conditions. The POH can't tell you how fast you'll fly, how far, or how long, unless you lean. Many pilots think that leaning is only for high altitudes; however, the truth is that **leaning is appropriate at any altitude as long as the engine is operating at less than 75 percent power.** (Consult your POH for information on calculating percentage of power.) Some pilots and flight instructors perpetuate the myth that leaning the engine will result in burned valves. This is not true. A properly leaned engine burning the recommended fuel will not exceed temperature tolerances.



If leaning is so important, you'd think it would be one of the first things you learn in flight training. Unfortunately that's not the case. Most early training flights are short and the power is adjusted frequently. Fuel consumption isn't an issue when departing with full tanks for a flight of an hour or less – so it's easier to leave the mixture rich. Many instructors don't teach leaning until the cross-country stage …and some never do.

Students who do all of their flying with rich mixtures probably won't lean as rated aviators either, and that can spell trouble when they try to get book range and endurance performance. Failure to lean is commonly cited as a factor in fuel exhaustion accidents.

Learn how to lean your airplane, and make leaning a habit on every flight. There are three ways to do it and general guidelines are presented below. ***For specific information, see your airplane's POH or the engine manufacturer's operating instructions. Student pilots should insist their instructors train them on leaning procedures.***

Leaning manually On basic airplanes, set the cruise power and lean the mixture until the engine runs rough. Then enrich the mixture slowly until the engine smoothes out. You may see a slight increase in rpm before the engine starts to roughen. If you need to climb to a higher cruising altitude, enrich the mixture before adding power – if you are at or above 75 percent power – and then lean again when you level at your new altitude.

Leaning with EGT Many airplanes are equipped with exhaust gas temperature gauges, or EGTs. As the mixture is leaned the combustion temperature increases up to a point or peak. If the mixture is leaned beyond that peak, combustion temperature will decrease because there won't be enough fuel to maintain the high temperature. The most economical mixture setting is usually obtained near peak EGT. For best power, lean to peak and then enrich by 75 to 125 degrees. This will vary by engine type and installation.

Leaning with TIT Pilots of some turbocharged airplanes lean with a turbine inlet temperature (TIT) gauge. Consult your POH for instructions.

Leaning for takeoff At high-density-altitude airports, you'll have to lean before takeoff to get proper takeoff power. Consult the POH for details.

The Danger of Carburetor Icing

As air moves through a carburetor its temperature drops and, if conditions are right, water vapor within the air can condense and form ice that restricts the flow. Most carbureted aircraft are equipped with pilot-operated controls that route heated air to the carburetor to melt the ice and keep it from re-forming.

Operating with carburetor heat will result in a richer mixture because the heated air is less dense than ambient air. Pilots should lean while operating with carburetor heat and enrich when carburetor heat is no longer needed.

Many aircraft engines are fuel-injected. Here the fuel is injected directly into the cylinders where it is mixed with air and ignited. Fuel-injected engines can't develop carburetor ice but can, under certain conditions, develop ice restrictions in their air induction path.

A private pilot was en route from Boston, Massachusetts to a nontowered airport in northern Virginia. Shortly after passing Dulles International Airport, the engine failed due to fuel exhaustion. The airplane was destroyed and the occupants were severely injured in the night, off-airport landing. The pilot stated that he had made the trip many times before with enough fuel to reach his destination but, on this flight, carburetor heat was applied shortly after takeoff and remained on until the landing. The richer mixture resulted in running out of fuel approximately 10 miles from his destination. **Note:** Although he was running a richer mixture than usual, it's unlikely that the pilot landed with the required fuel reserve on his previous flights. When asked what the fuel gauges indicated before the landing the pilot admitted that they showed empty but added that his flight instructor had told him fuel gauges were often inaccurate and not to be trusted.

Estimating Fuel Consumption

Using tabular data, charts, or graphs, the POH shows fuel consumption for various power settings. This will give you some idea of what the fuel consumption will be, but remember: ***Fuel consumption figures are based on a properly leaned engine operating at a given power setting.*** Pilots who have a lot of experience with one airplane have a good idea what their fuel consumption will be, but until you get to know your airplane, we recommend that you add a gallon or two per hour to your fuel consumption estimate.

One way to get to know your fuel consumption is to estimate how much fuel your airplane will take at each fuel stop. Comparing this estimate with what actually goes into the tank is an excellent way to develop fuel sense. Many pilots make a mental game out of this – seeing how close the fuel delivery is to their prediction.

In flight, recalculate range and endurance hourly. Compare your range calculation with the distance to your destination to make sure you maintain an adequate fuel reserve. By recalculating range and endurance hourly, you are monitoring your fuel status and can make adjustments to your flight plan for unforecast winds, or weather deviations.

Your GPS can be a valuable aid in managing fuel consumption. The GPS provides accurate information about ground speed and the associated time to destination, which are essential parameters for determining adequate fuel reserves.

FAA regulations ***require*** a minimum fuel reserve for all operations but we recommend a more conservative approach. ***Pilots should never land with less than an hour of reserve fuel in their tanks.* This does not mean searching for an airport when approaching the one-hour reserve. It means *be on the ground.***

Before departing on a cross-country flight, the instrument-rated commercial pilot of a Piper Cherokee Six requested that the two main tanks and two auxiliary tanks be "topped"; however the FBO subsequently stated that only the mains were filled. En route, the pilot became aware of a low fuel condition. A passenger stated that the pilot considered landing at a towered airport for fuel but, having a radio problem, elected to continue to a nontowered airport. The engine lost power about five miles from the field and an off-airport landing was made. The pilot and two passengers died. The three remaining passengers were seriously injured. **Note:** This accident, and many other fatal fuel related accidents, occurred at night. The added difficulty of making a successful off-field landing at night makes additional fuel reserves a very good idea when flying after dark.

Extending the Range

Long deviations around weather, stronger than forecast headwinds or, as in the case above, discovery of a low fuel condition may occasionally require pilots to maximize fuel economy. So let's take a look at some ways to conserve fuel.

- Slow down – You'll burn less fuel if you cruise at a lower power setting.
- Fly with the wind – If you have a choice of relatively equal-distant fuel stops pick the one that's downwind. You may have to back track but you'll burn less fuel and get there faster.
- Lean for best economy – Consult the POH for best economy/long endurance power settings and leaning procedures.

Obviously pilots should make adjustments to their flight plan before fuel becomes a critical issue, but if you're low on fuel or, worse yet, dipping into the reserve, land as soon as possible. Don't wait for the FBO with the best price or the preferred credit card. **Note:** Pilots coordinating with ATC and running low on fuel can declare a ***minimum fuel advisory.*** This means delays cannot be tolerated and will likely result in an emergency situation.

Managing Fuel in Flight

To maintain lateral balance in airplanes that cannot simultaneously feed fuel from both wings, drain the tanks in equal increments. For example, after takeoff, fly one hour on the right wing tank, then two hours on the left wing tank to keep the weight equally balanced. Using these hourly increments makes it easier to remember the time to switch tanks. Many pilots mount a timer in plain view to remind them to switch tanks.

Managing Fuel from Auxiliary Tanks

Many airplanes are equipped with auxiliary fuel tanks that don't always feed the engine directly. Fuel from some auxiliary tanks is transferred to the main tanks and then fed to the engine. Other auxiliary tanks supply fuel directly to the engine. On most aircraft, takeoff and landing MUST be on the main tanks because of possible fuel flow interruption.

A pump failure before transfer is complete could severely limit aircraft range, so prudent pilots transfer fuel as soon as there's room for it in the main tanks.

The ***rate*** at which the transfer pumps move the fuel from the auxiliary tanks to the main tanks must also be considered. If you transfer fuel faster than you burn it you'll have to wait until there's room in the main tank to receive it. If the reverse is true, you can't transfer fuel to an empty main tank and feed the engine at the same time.

A reasonable recommendation would be to run an hour on each main tank and then transfer fuel from both auxiliary tanks at the same time. That will accomplish two things:

- You'll maintain longitudinal balance on the airplane.
- If you're setting out on a maximum range trip – a long over-water leg for example – you'll know if you have a fuel transfer problem in plenty of time to turn back to your point of origin.

Refer to your manual to learn how and when to transfer fuel to the main tanks.

The Fueling Process

Most FBOs that provide fuel also have line personnel to dispense it, but there is a growing trend to self-service aviation fuel facilities. Whether supervising the service or performing it themselves, pilots should know something about the fueling process.

- The first thing to do in the fueling process is to **make sure there will be fuel and some way of dispensing it when you arrive.** At large FBOs operating 24/7 this isn't likely to be a problem but be sure to call ahead if you don't want to take a chance on spending a night in the airplane. There's nothing quite so disappointing to pilots and passengers than to call the after hours phone number posted at the FBO and hear the phone ringing in the empty line shack. **Note: It's not a bad idea to buy some fuel wherever you land. It may be a little more expensive than waiting until you find a really good price, but if we don't support the small FBOs they may not be there when we need them.**
- **Make sure the airplane is grounded.** Static electricity in your hair or on your clothes can be annoying. Static electricity around gasoline can be explosive with deadly results. This is why line personnel attach a ground wire from the fuel truck or fuel island to the airplane before fueling.
- **Make sure the proper type and grade of fuel will be used.** Most fuel trucks and pumps are clearly marked. If not – or if you're in any doubt as to the quality of the fuel – sample the fuel before putting it into your airplane.
- **It's easier to fuel high-wing airplanes with a ladder** than to use steps attached to the airplane. If possible have someone hand the fuel hose to you after you're in position.
- **If you intend to fly with full fuel make sure the tanks are absolutely full.** If the airplane is not on a level surface it will be impossible to fill the tank completely. When fuel tanks are interconnected, as in many Cessna models, fuel will flow to the lower tank if the airplane is not level. This can result in loss of fuel through the fuel tank vents, and that can have negative environmental as well as operational consequences. Fuel expands when heated so if your plane is filled with cool fuel from underground tanks, you may lose some fuel through the vents due to expansion. Similarly, a full tank in mid-afternoon may show less than full after it's cooled overnight. Some airplanes, such as the Cessna 210, require each tank to be fueled at least twice to make sure they are both full. Due to the geometry of the wing and internal tank baffles, it takes some time for the fuel to diffuse into the tank. Fill one tank, then the other. When the process is repeated, an additional four to five gallons can be added to each tank – enough to fly for about 45 minutes. **Note: Obviously, fueling operations should cease when there's a thunderstorm on or near the airport.**
- **Sample the fuel you've received.** It's a good idea to pay for the fuel and attend to other last minute details before sampling. That way any contaminants will have some time to settle to the fuel tank sumps before you check them.

  - Take a generous sample. Fill the sample container at least once from each drain.
- **Make sure you have the proper fuel type and grade.**
  - Hold your sample container against a white background to gauge the color of the fuel.
  - The most common aviation gasoline is 100LL (low lead), which is a pale blue color; 80 octane gasoline is red. You're unlikely to find straight 100 octane (green).
  - **Jet fuel is clear or slightly yellow** in color and it takes a high concentration of jet fuel in gasoline before you'll notice a color change. A better test is to put a drop of fuel on plain bond paper or a business card. Avgas will evaporate quickly. Jet fuel takes longer and will leave a ring of discoloration on the paper.
  - **Does the sample smell like gasoline?** Jet fuel has a distinctly different odor and is oily to the touch.
- Finally, **make sure the fuel caps are secure.** If you lose a fuel cap in flight, fuel can siphon out of the tank at an alarming rate, and if you're in a high-wing airplane or flying at night, you won't be able to see it. Many pilots secure fuel caps for themselves rather than having line service do it. **Note: When you're securing the fuel caps it's also a good time to check the cap seals. Faulty**

or worn cap seals are the principal way that water gets into aircraft fuel tanks.

How Do I Dispose of the Sample?

There is much debate as to how fuel samples should be disposed of. Apart from being an obvious fire hazard, fuel can destroy asphalt ramps over time and evaporated fuel contributes to pollution, so it's not a good idea to throw samples on the ground or into the air. On the other hand, many pilots shudder at the thought of pouring samples back into the tank, but if the sample is uncontaminated – why not put it back?

Some airports provide fire safe containers to dispose of fuel samples; at most other locations the debate rages on and will not be resolved in this Safety Advisor.

The Bottom Line

Of all GA accident causal factors, fuel ought to be the easiest to address. We hope this Safety Advisor has provided the tools and information you need to move GA closer to our goal of ***Safe Pilots – Safe Skies***.

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